

Assessment of CFSv2 terrestrial hydrologic processes

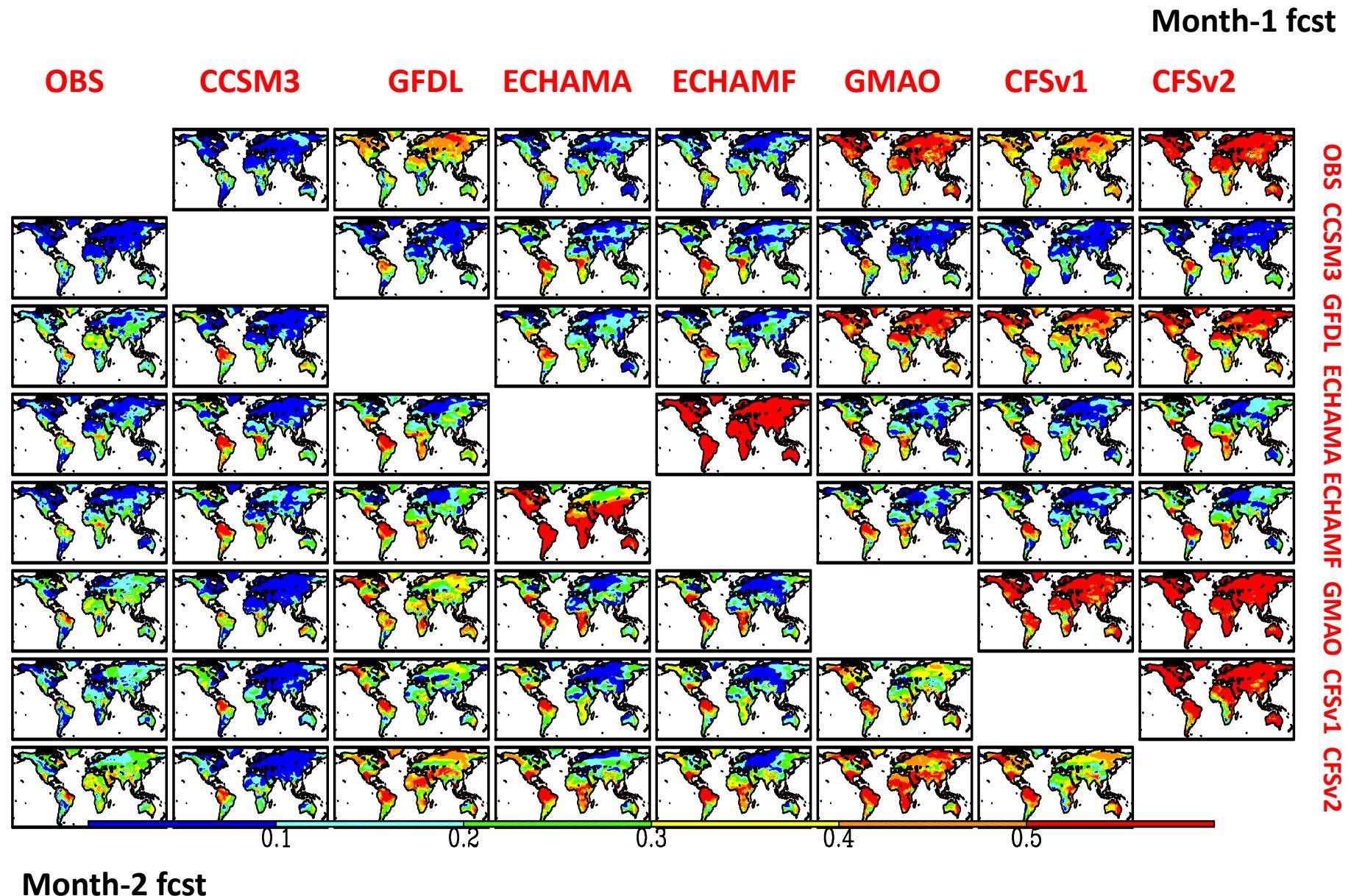
Eric F Wood
Princeton University

CFSv2 Evaluation Workshop
April 30 – May 1, 2012

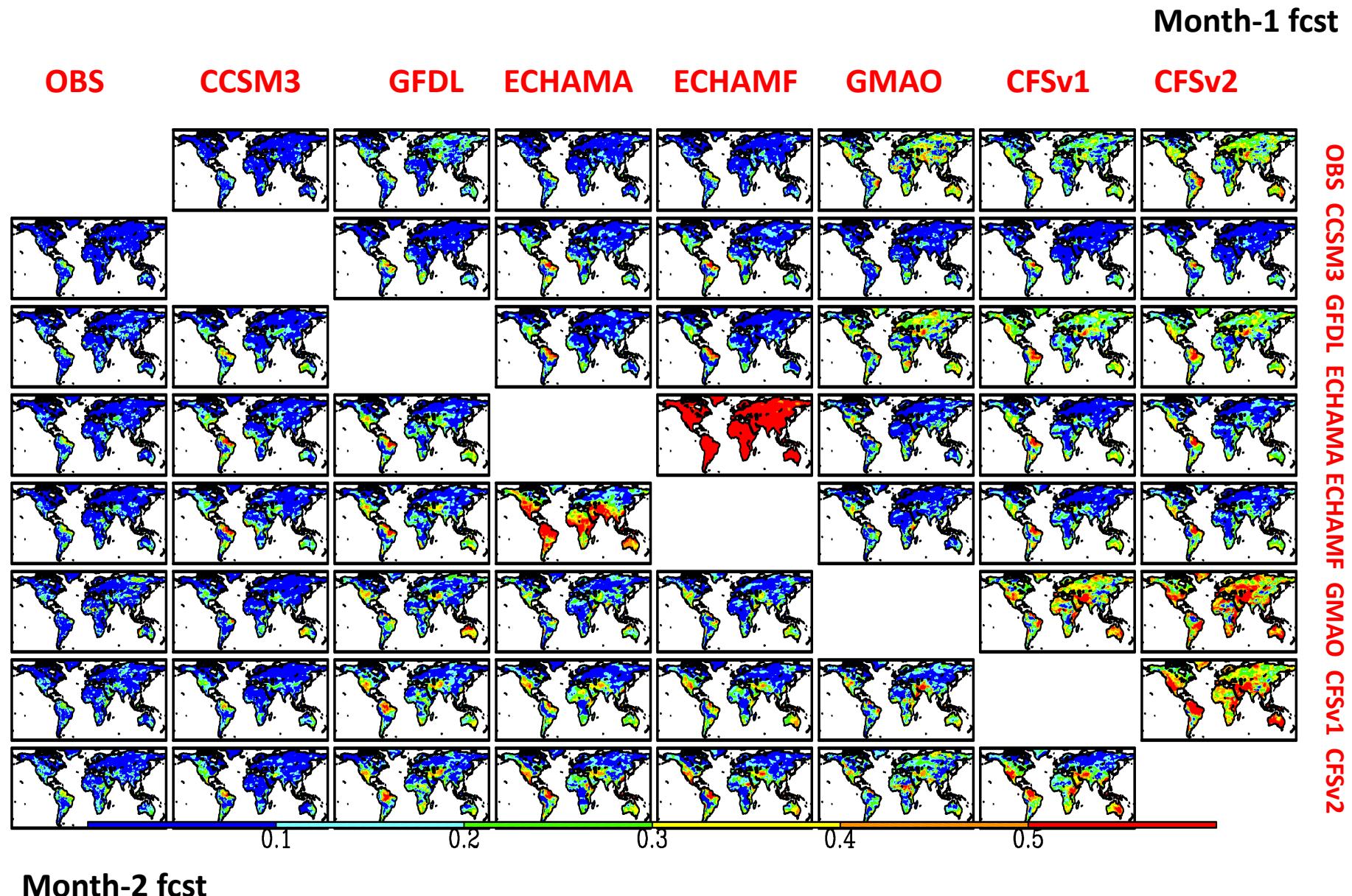
CFSv2 and CFSR issues related to land hydrology and comparisons over land

1. Comparisons of CFSv2 and NMME skill over land. This is critical for driving seasonal hydrologic forecast systems.
2. Areas predicted under drought (CFSR)
3. Seasonal Hydrologic Forecasting system and drought forecasting (CFSv1 and CFSv2).
4. Land-atmospheric coupling over the SE US
5. Hydrologic processes related to snow predictions. CFSv2 uses Noah 2.7 as its LSM while EMC runs Noah 2.8 in their NLDAS system.
6. Hydrologic sensitivity of Noah 2.7 compared to other LSM. Implications for basin discharge forecasts due to precipitation and temperature errors as well as using CFSv2 for decadal and long-term projections (e.g. COLA).

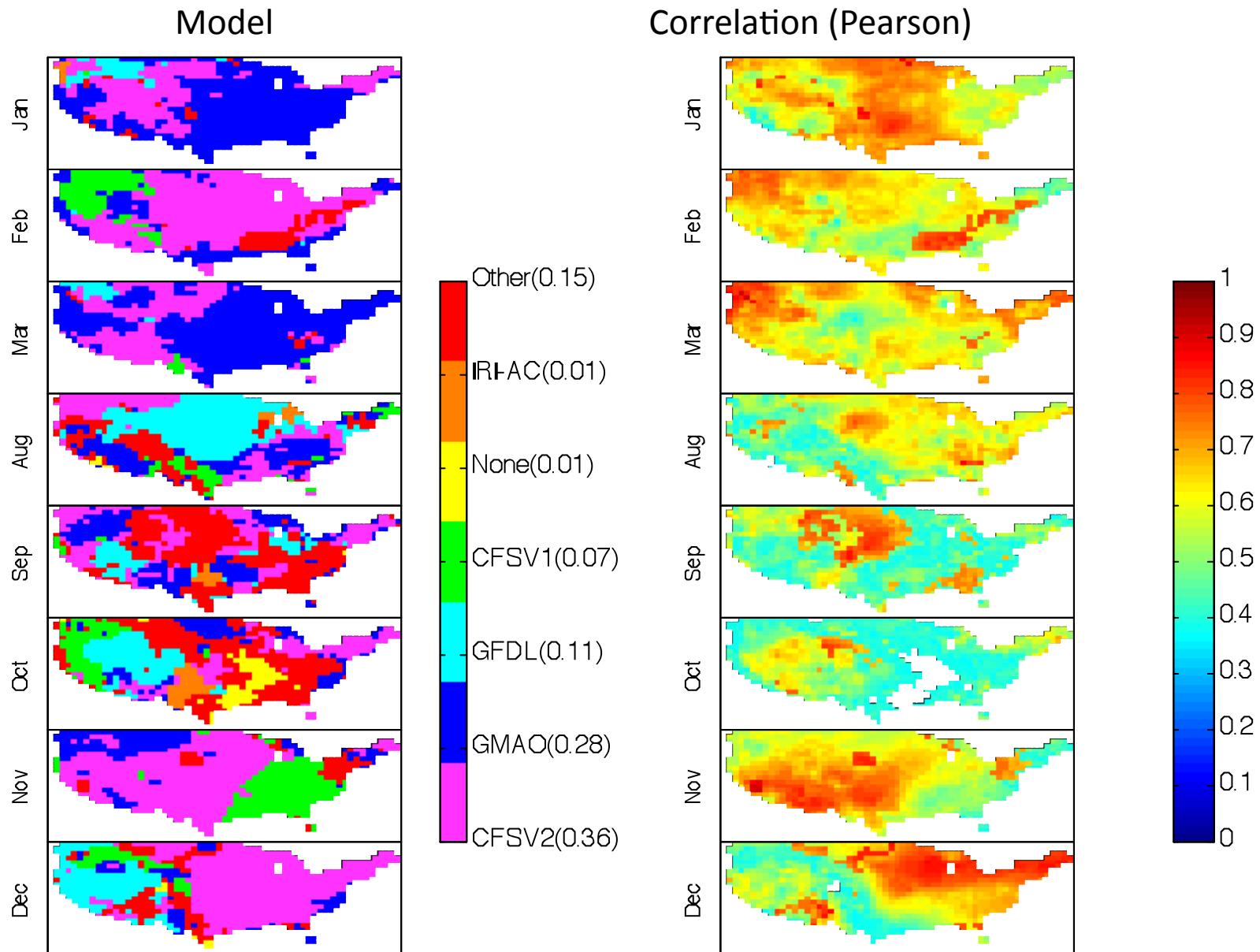
Covariance Matrix: T2M correlation (198201-200912, w/o seasonality)



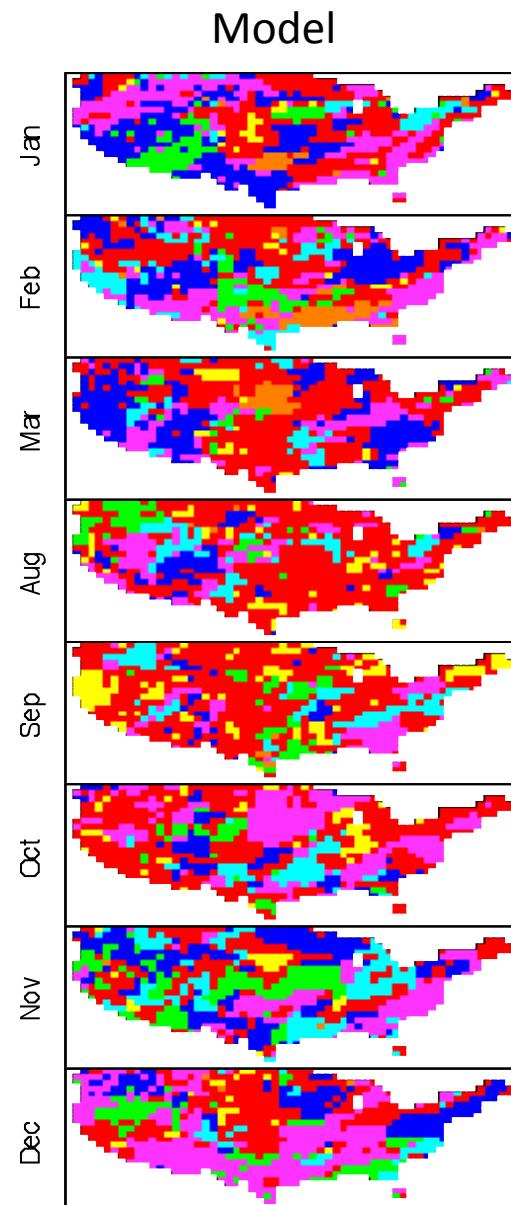
Covariance Matrix: PR correlation (198201-200912, w/o seasonality)



1 Month Temperature (significant at 95%)

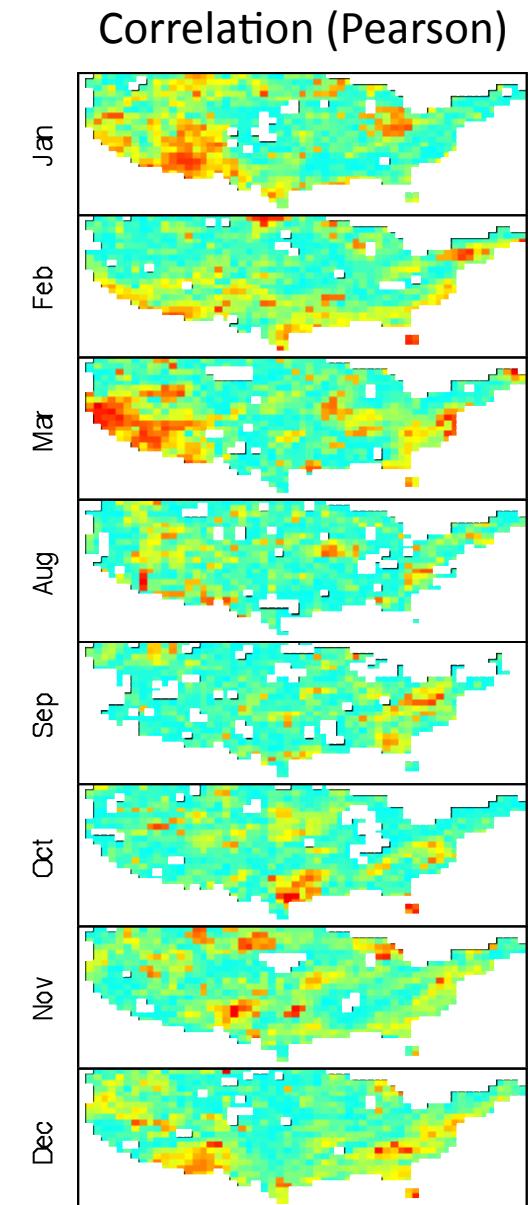


1 Month Precipitation (significant at 95%)



A vertical color scale legend with seven entries, each consisting of a colored square followed by text. The colors range from dark red at the top to light pink at the bottom.

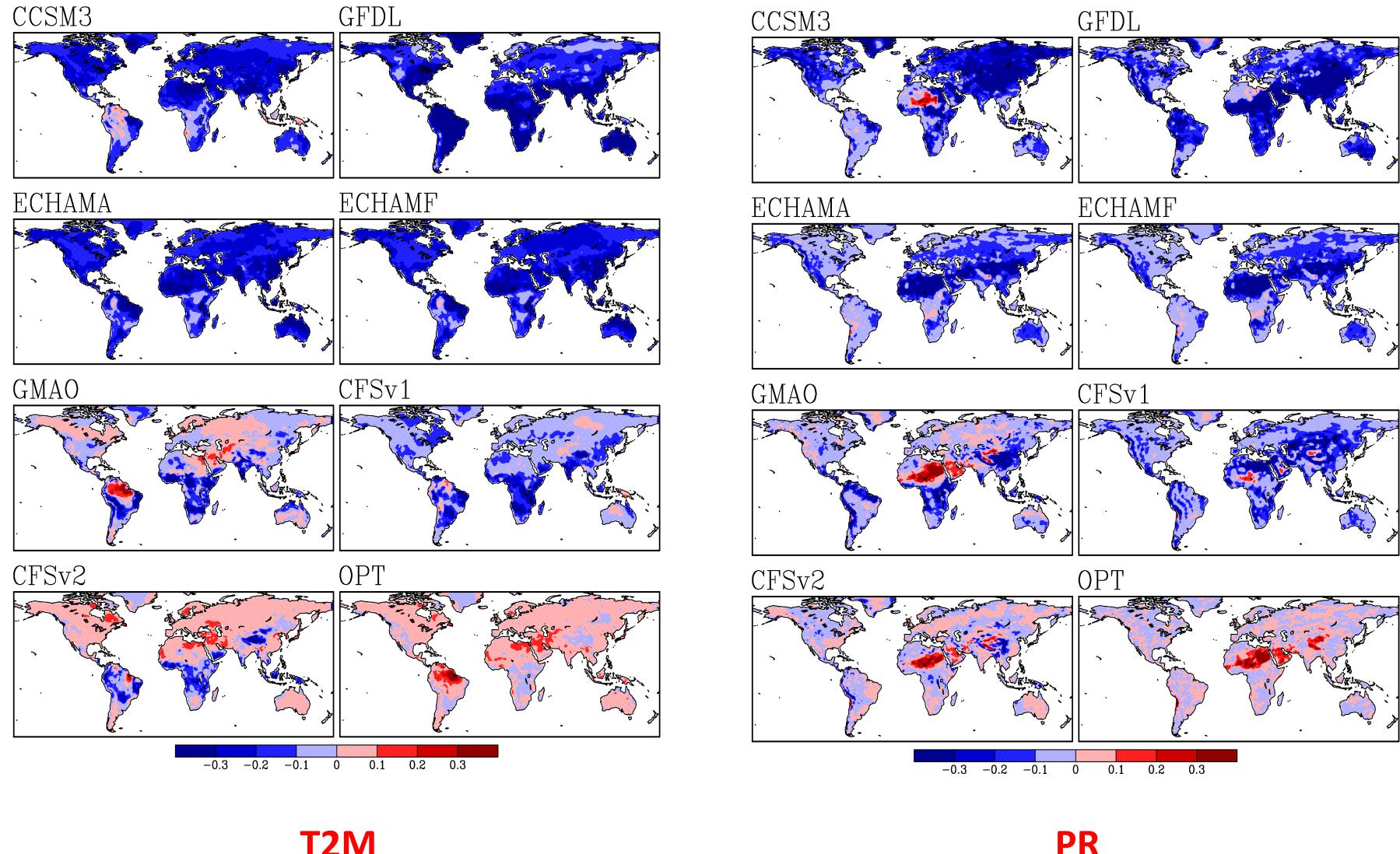
Model	Significance
Other(0.41)	Dark Red
IRFAC(0.02)	Orange
None(0.05)	Yellow
GFDL(0.08)	Light Green
CFSV1(0.08)	Cyan
GMAO(0.17)	Blue
CFSV2(0.20)	Pink



A vertical color scale legend with eleven entries, each consisting of a colored square followed by a numerical value. The colors range from dark red at the top to dark blue at the bottom.

Correlation	Value
0	Dark Blue
0.1	Blue
0.2	Cyan
0.3	Light Cyan
0.4	Light Green
0.5	Yellow
0.6	Orange
0.7	Red
0.8	Dark Red
0.9	Very Dark Red
1	Black

Change in skill score over equally weighted NMME for month-1 forecast averaged during Aug-Mar



Time Series of Soil Moisture Percentiles and Area in Drought: GLOBAL

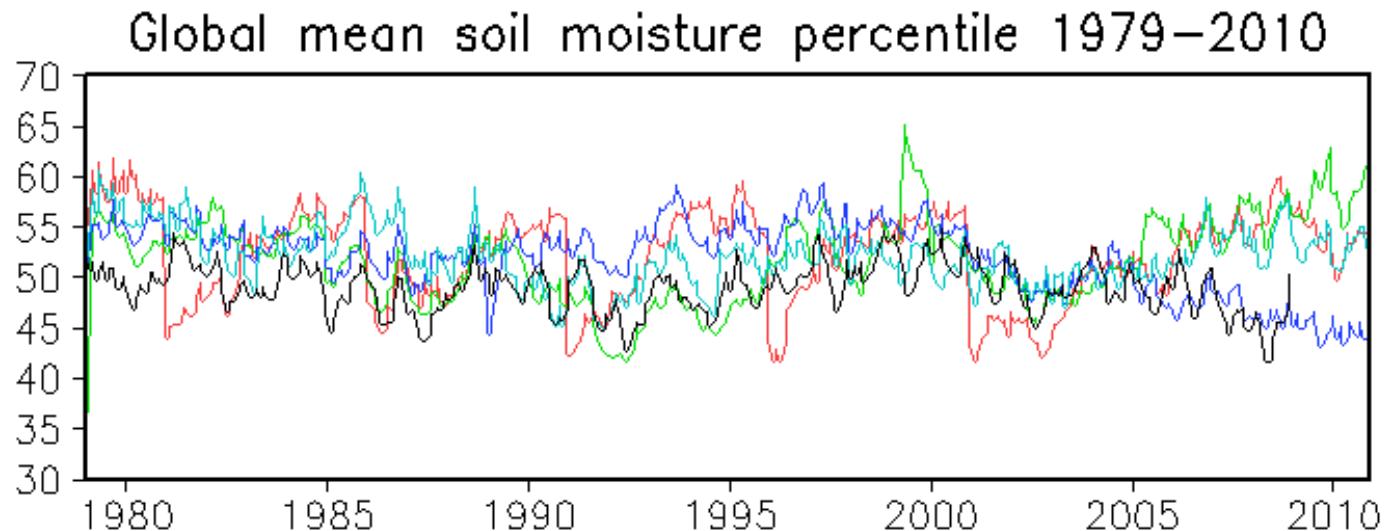
NLDAS2 MME

20CR

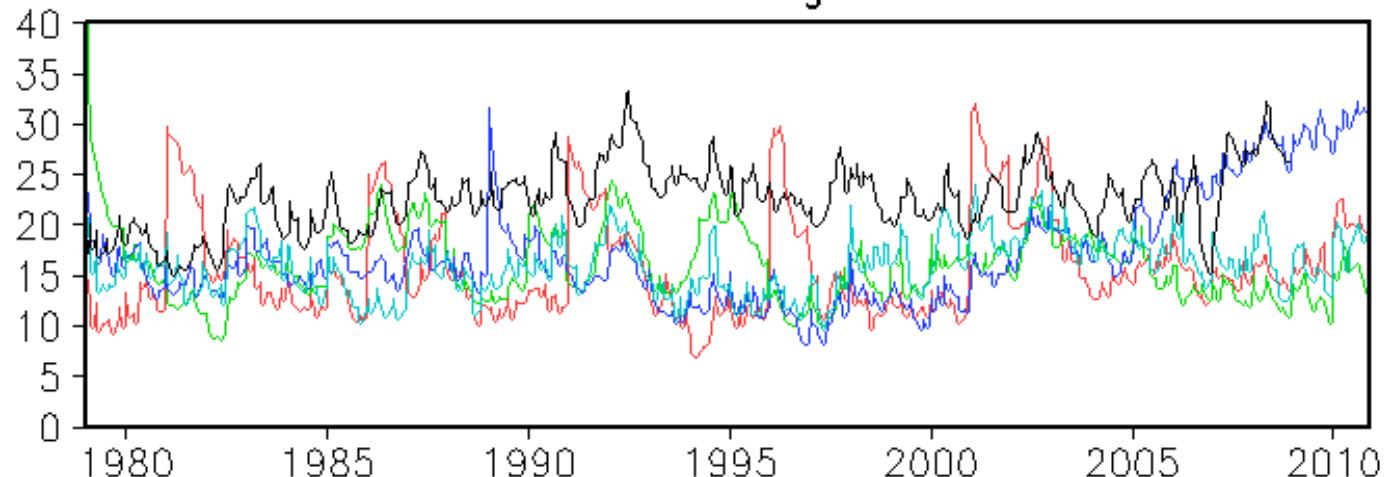
CFS-R

ERA-int

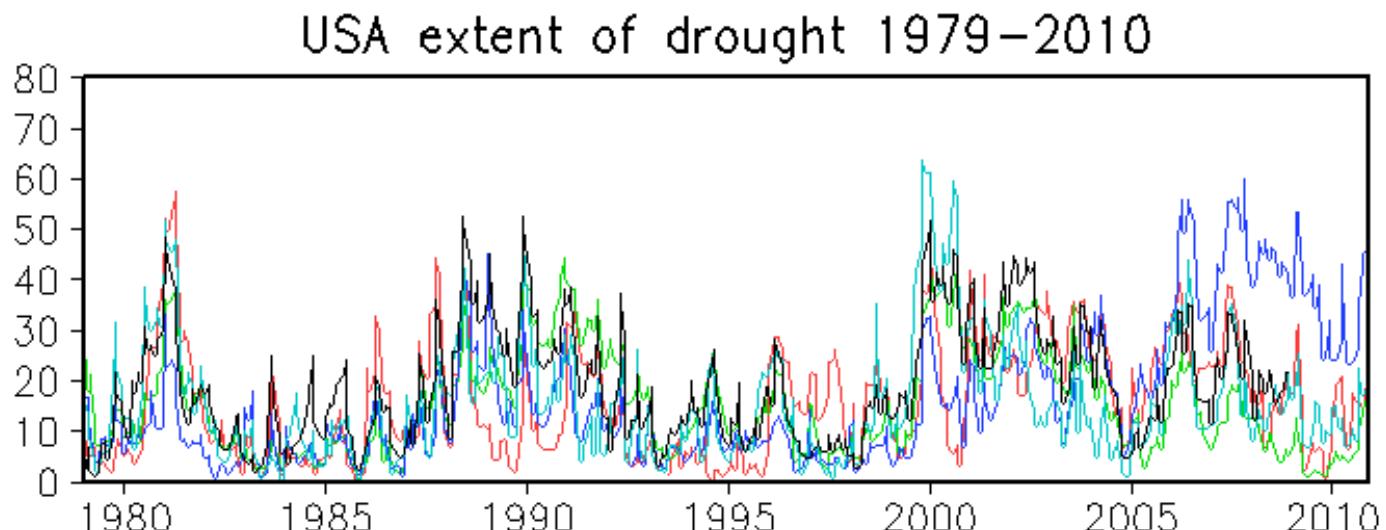
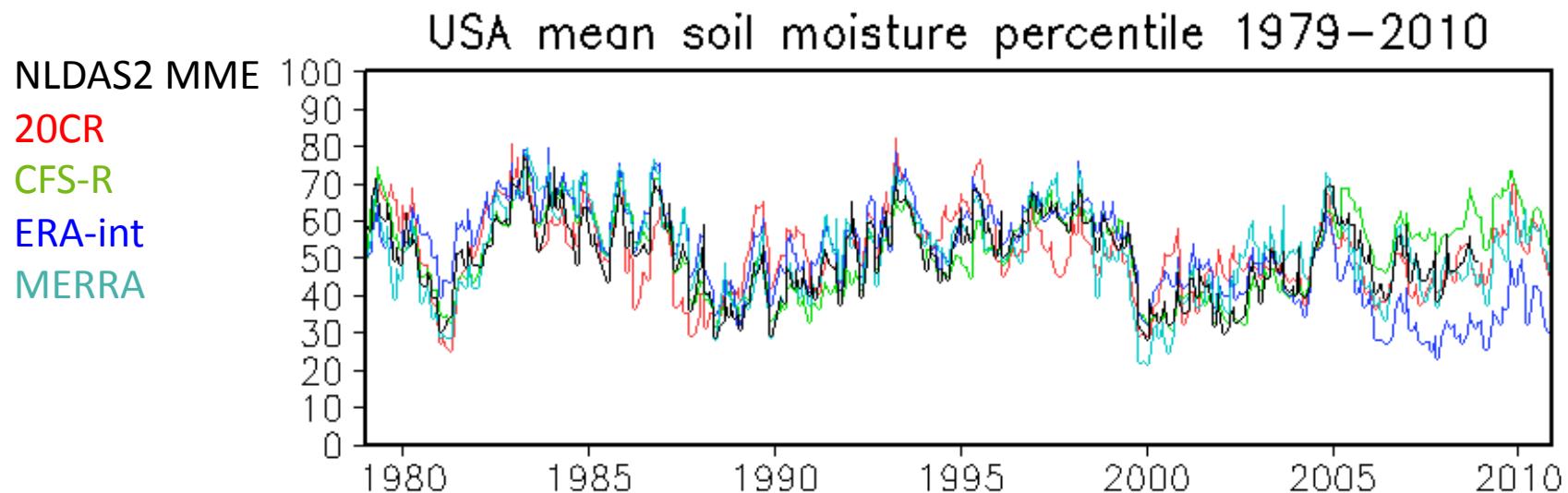
MERRA



Global extent of drought 1979–2010



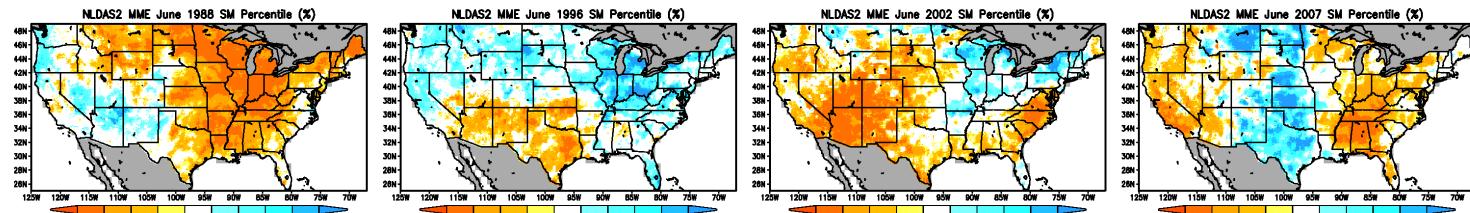
Time Series of Soil Moisture Percentiles and Area in Drought: USA



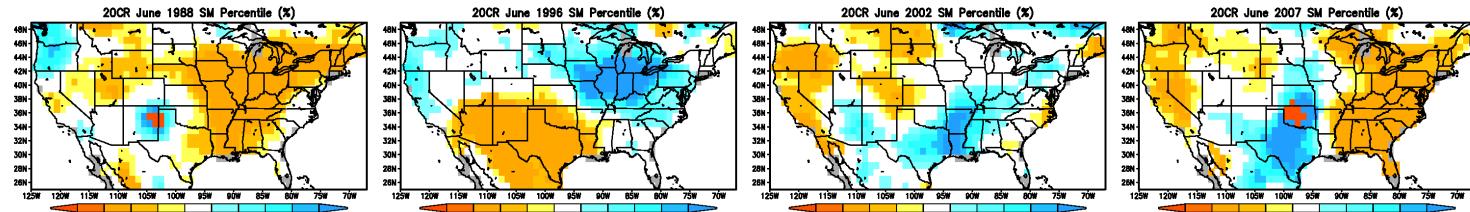
Representation of Drought Events

June 1988 June 1986 June 2002 June 2007

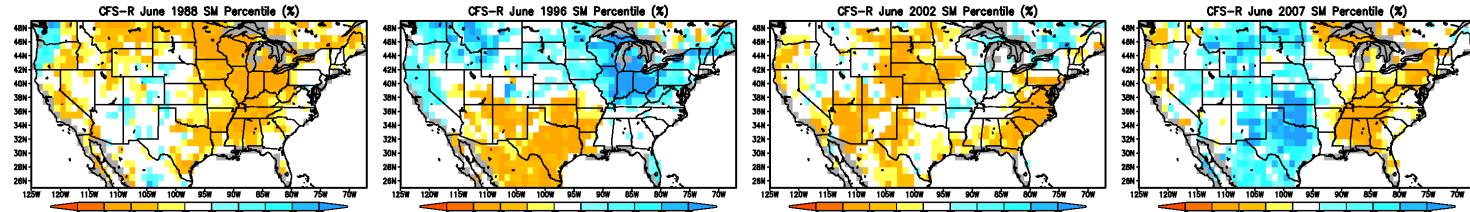
NLDAS2



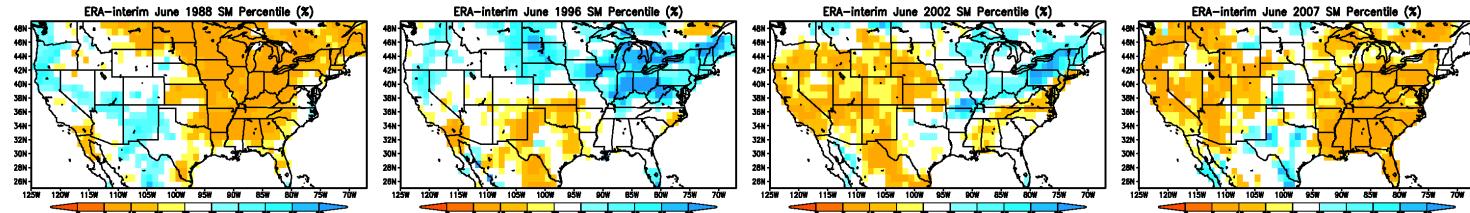
20CR



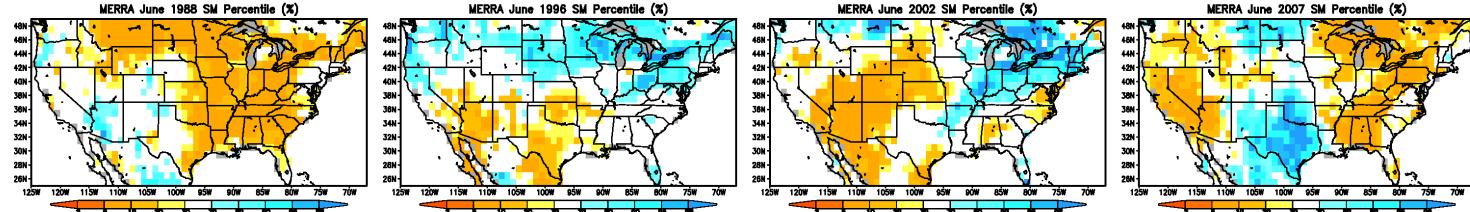
CFS-R



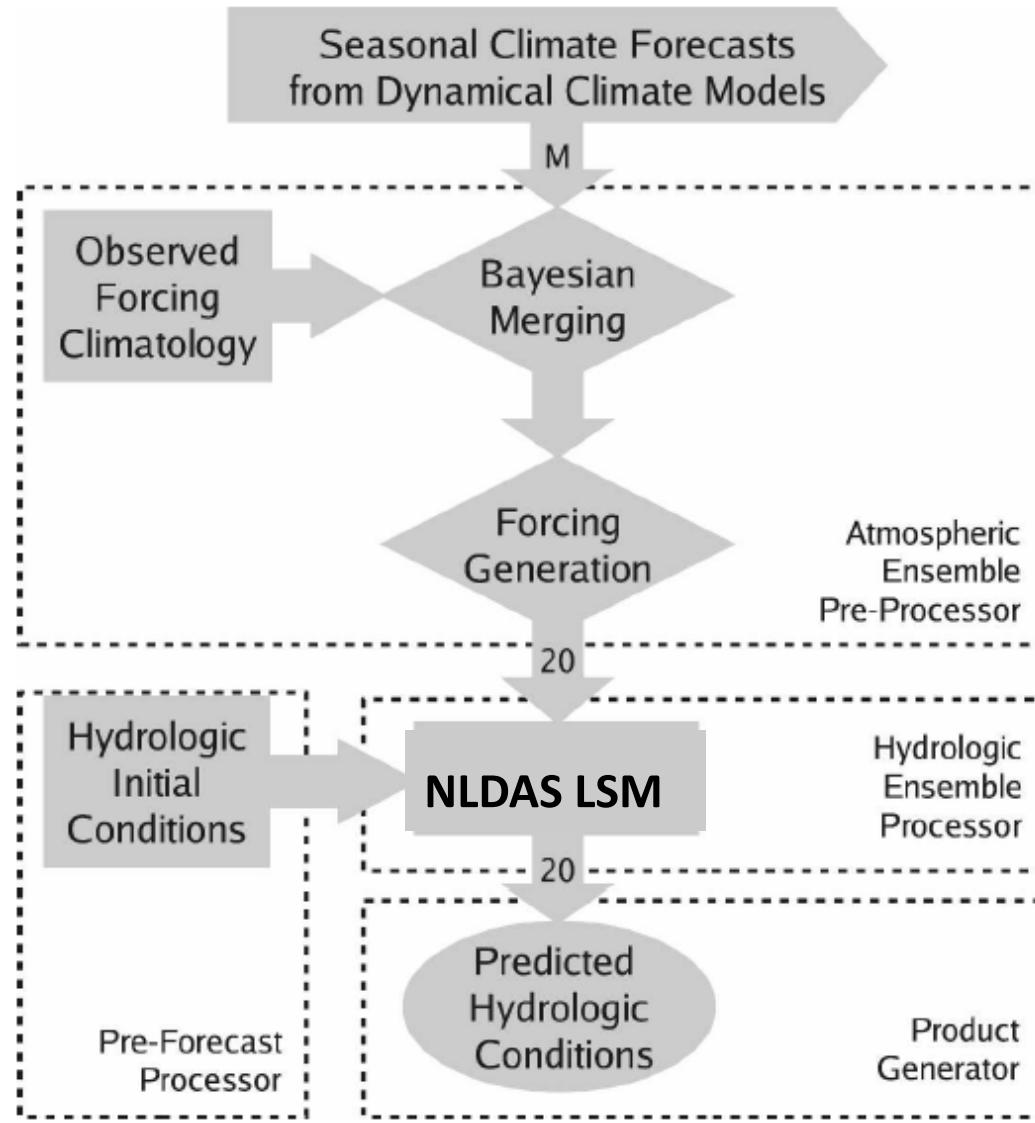
ERA-int



MERRA

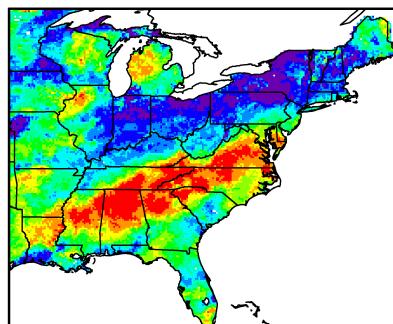


Schematic illustration of the seasonal hydrologic ensemble prediction system



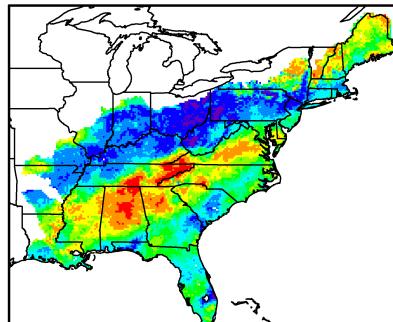
Soil moisture percentile in Jan 2008

VIC Offline Simulation Jan 2008

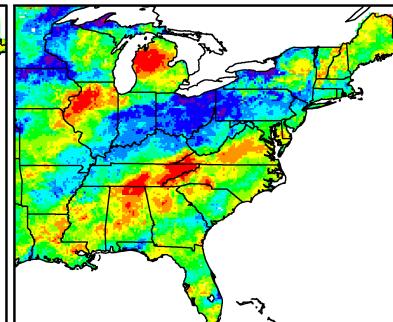


**VIC Off-line
(Control) for Jan-08**

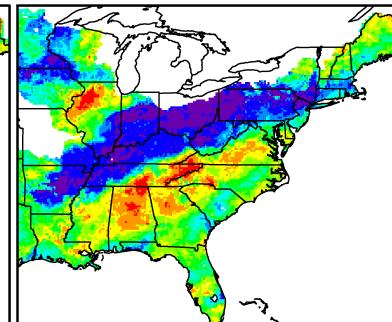
ESP Forecast (1 month Lead)



CFSv1 Forecast (1 month Lead)

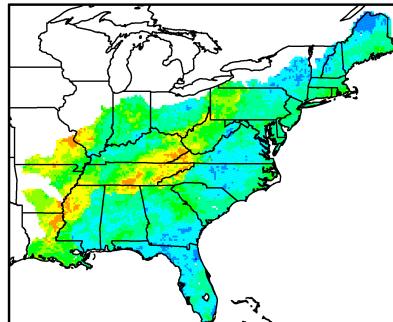


CFSv2 Forecast (1 month Lead)

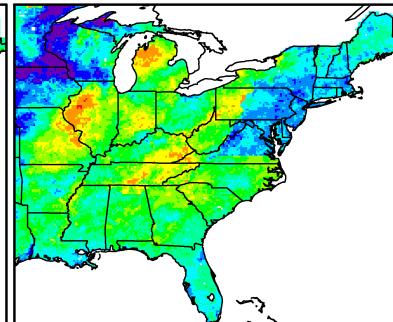


1 Month Lead

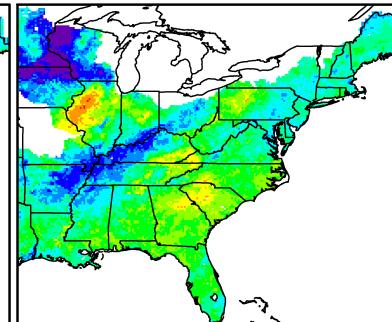
ESP Forecast (3 month Lead)



CFSv1 Forecast (3 month Lead)



CFSv2 Forecast (3 month Lead)



3 Month Lead



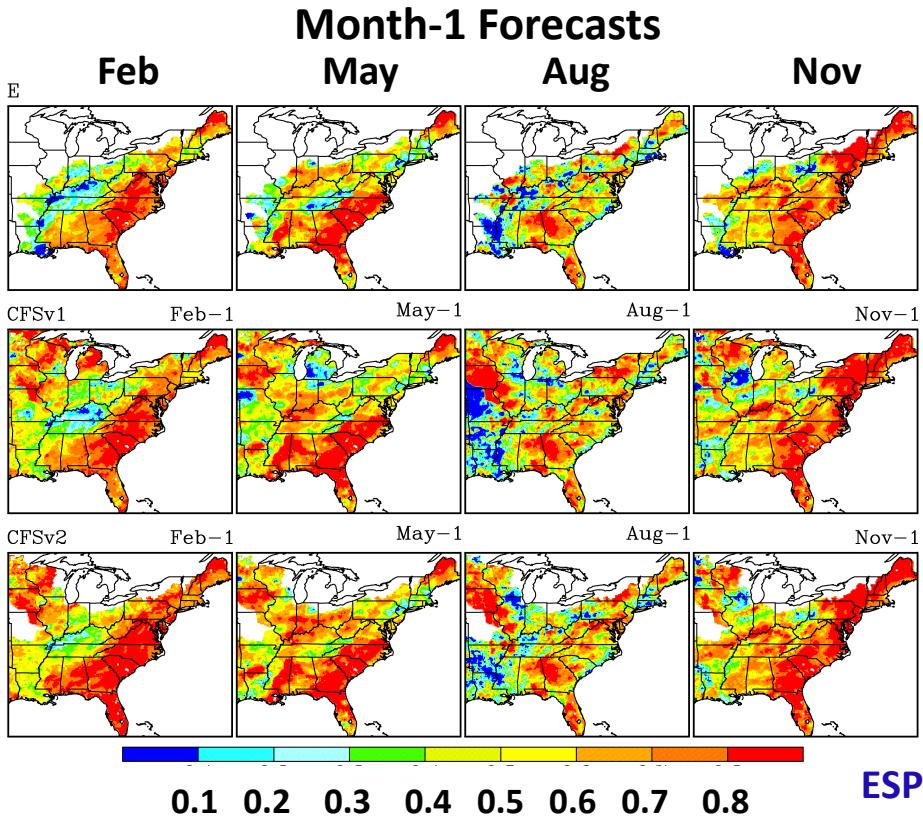
ESP

CFSv1

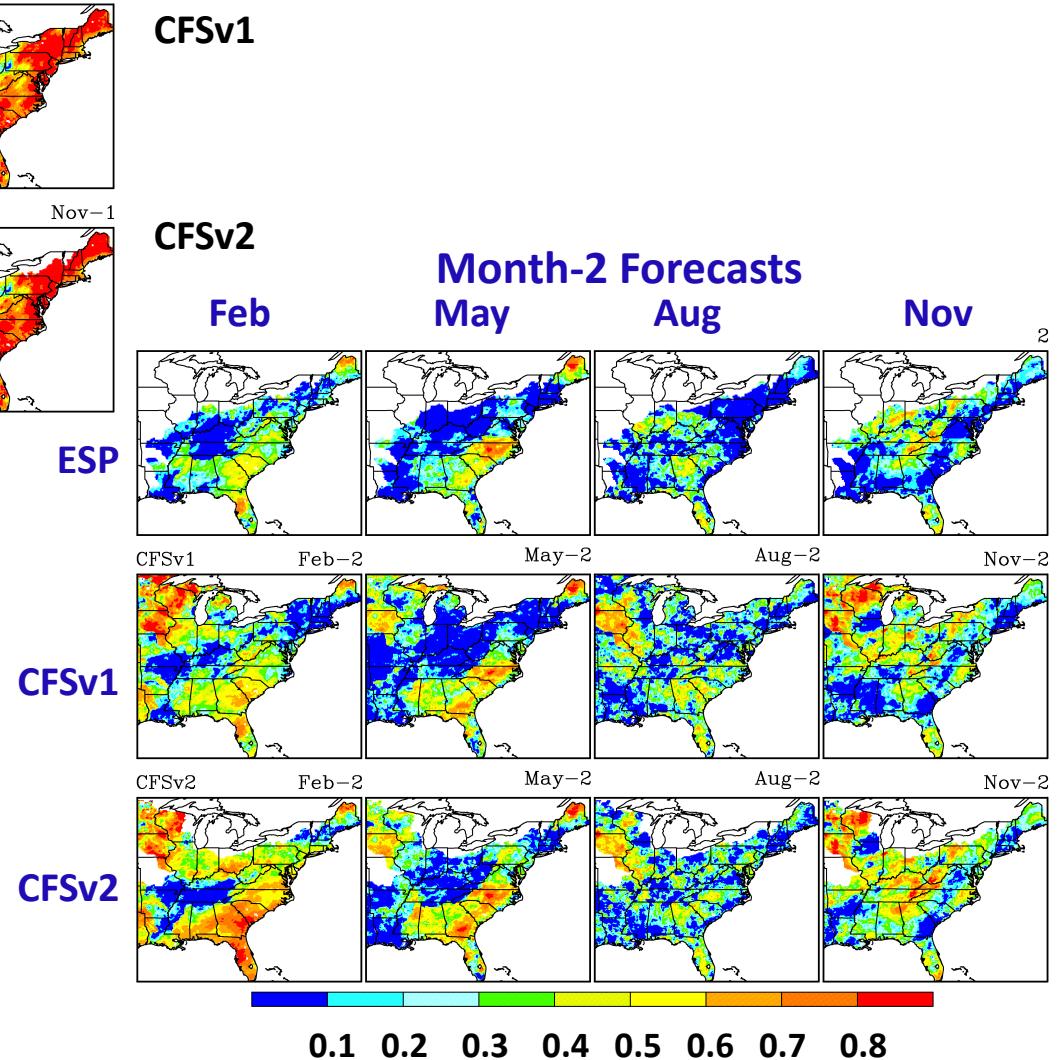
CFSv2

Princeton University



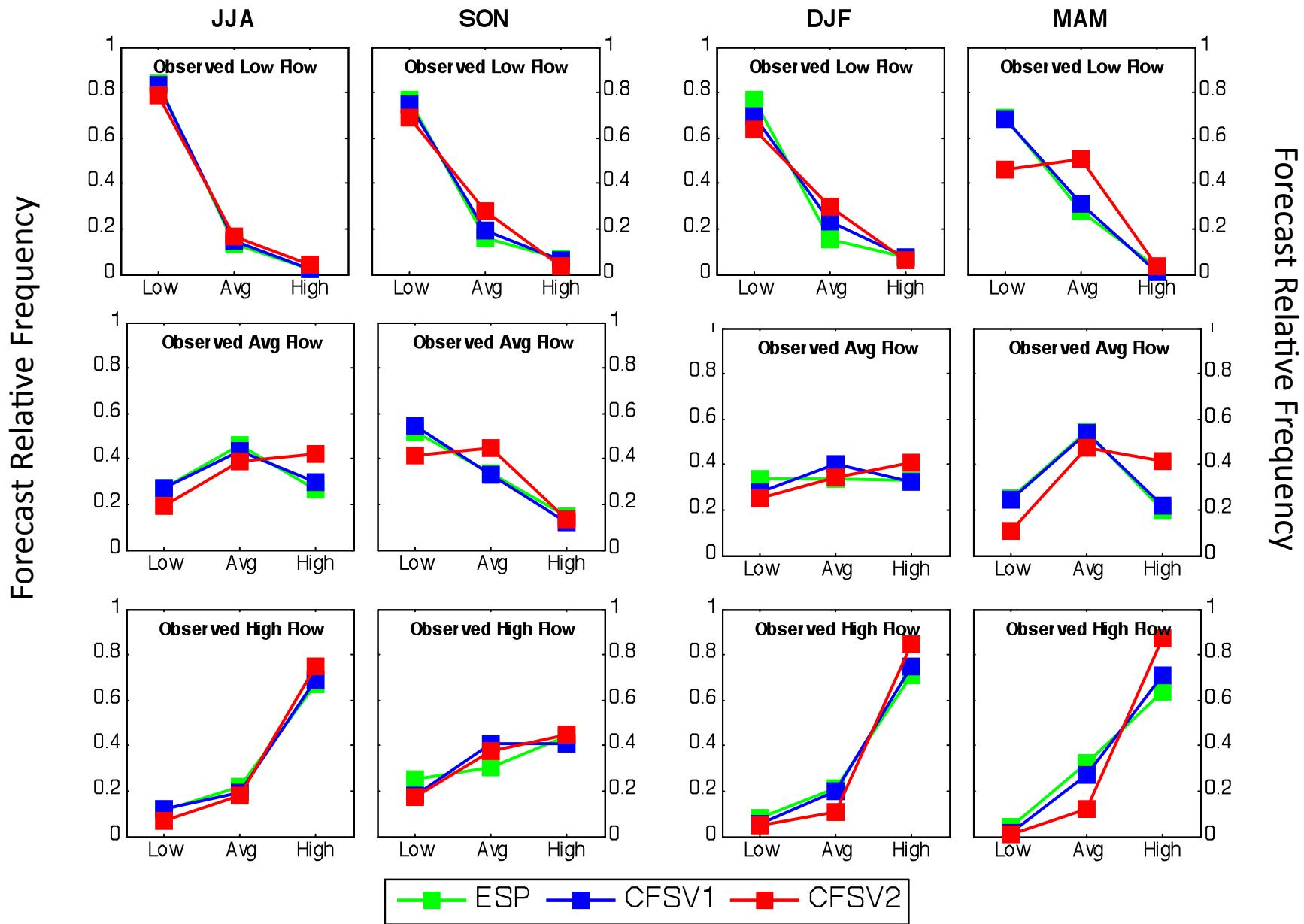


Correlation with Predicted Runoff for the first two months over Eastern US



- Cold season is better than warm season.
- Skill decreases dramatically in the second month.
- Due to the effects of initial conditions, CFSv1 and CFSv2 have more obvious improvement for month-2.

SE NIDIS, Seasonal Forecast Discrimination (month 1)



1 Month

6 Month

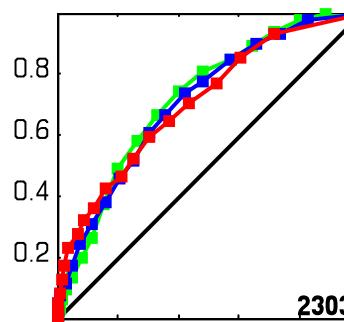
**Area Under ROC
Skill Score (ESP)**

Probability of Detection

Onset

Forecast of Low flow –
Forecast initiated from

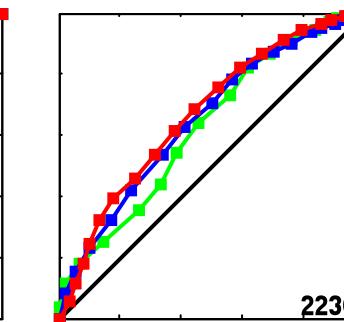
Avg. flow



Continuation

Forecast of Low flow –
Forecast initiated from

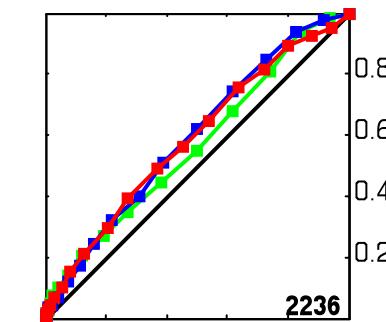
Low flow



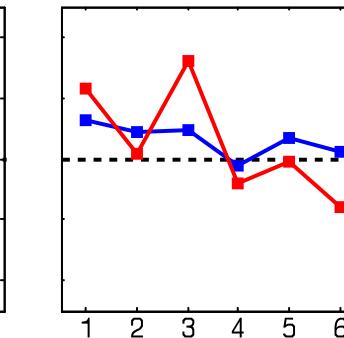
Recovery

Forecast of Avg. –
Forecast initiated from

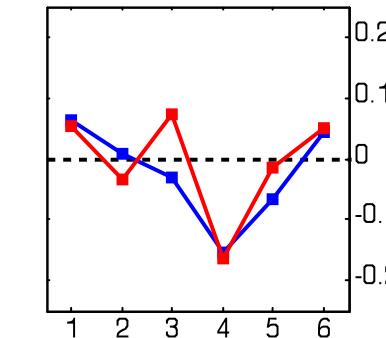
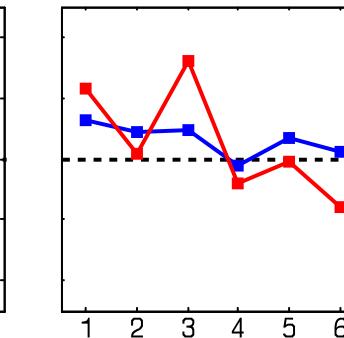
Low flow



Probability of False Detection

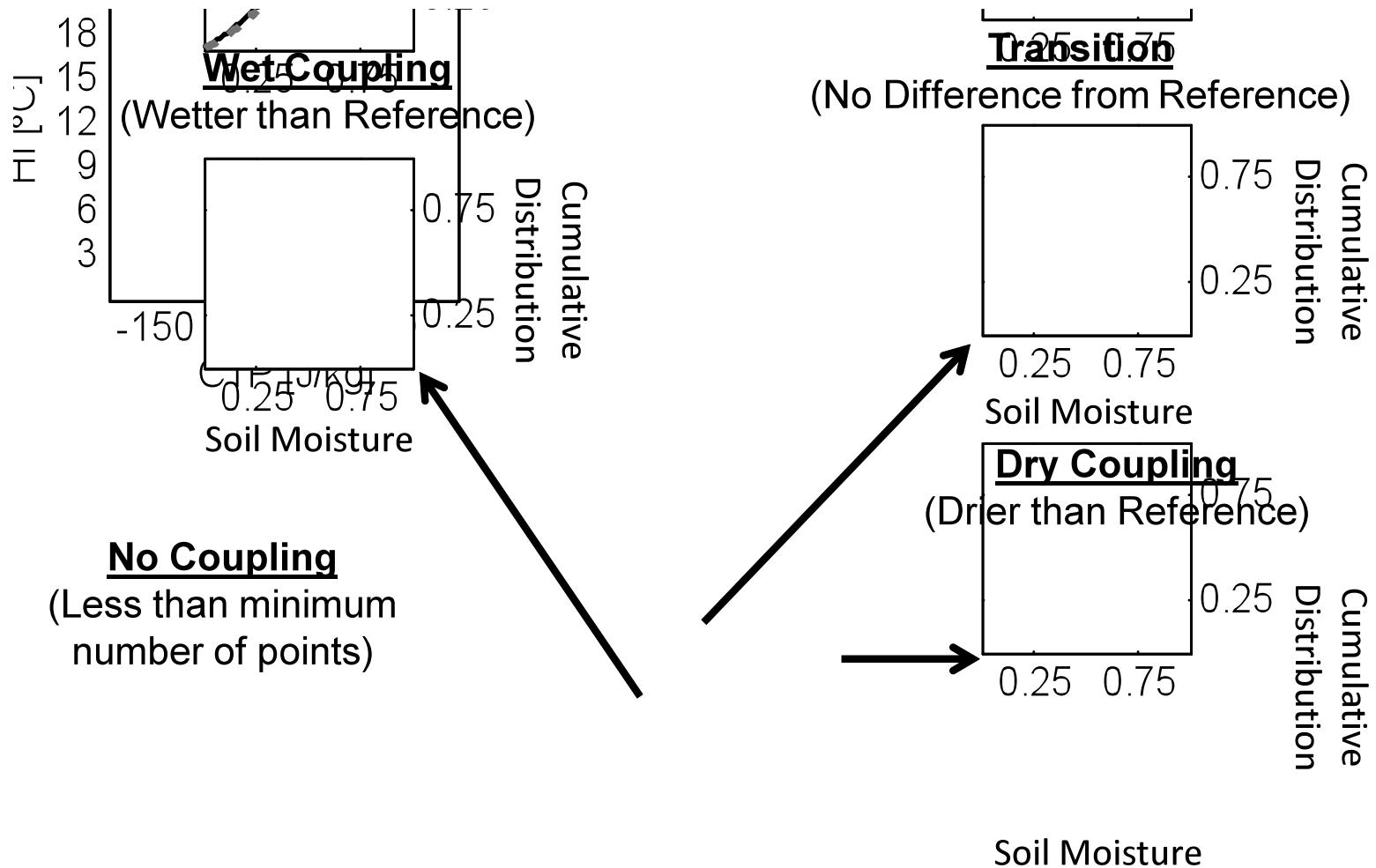


Lead Time



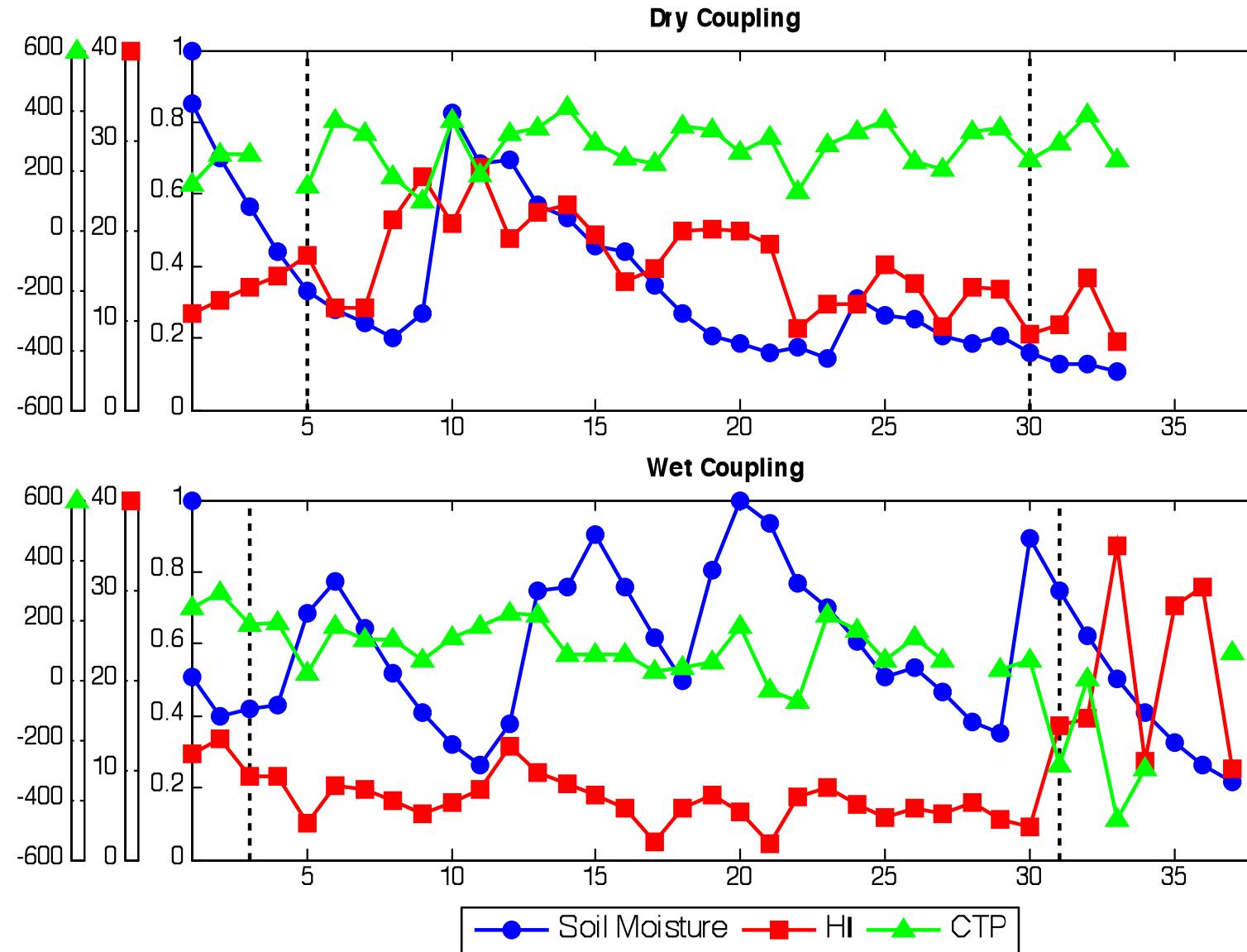
—■— ESP —■— CFSV1 —■— CFSV2

CFSv2 land-atmospheric coupling: Humidity Index – Convective Triggering Potential



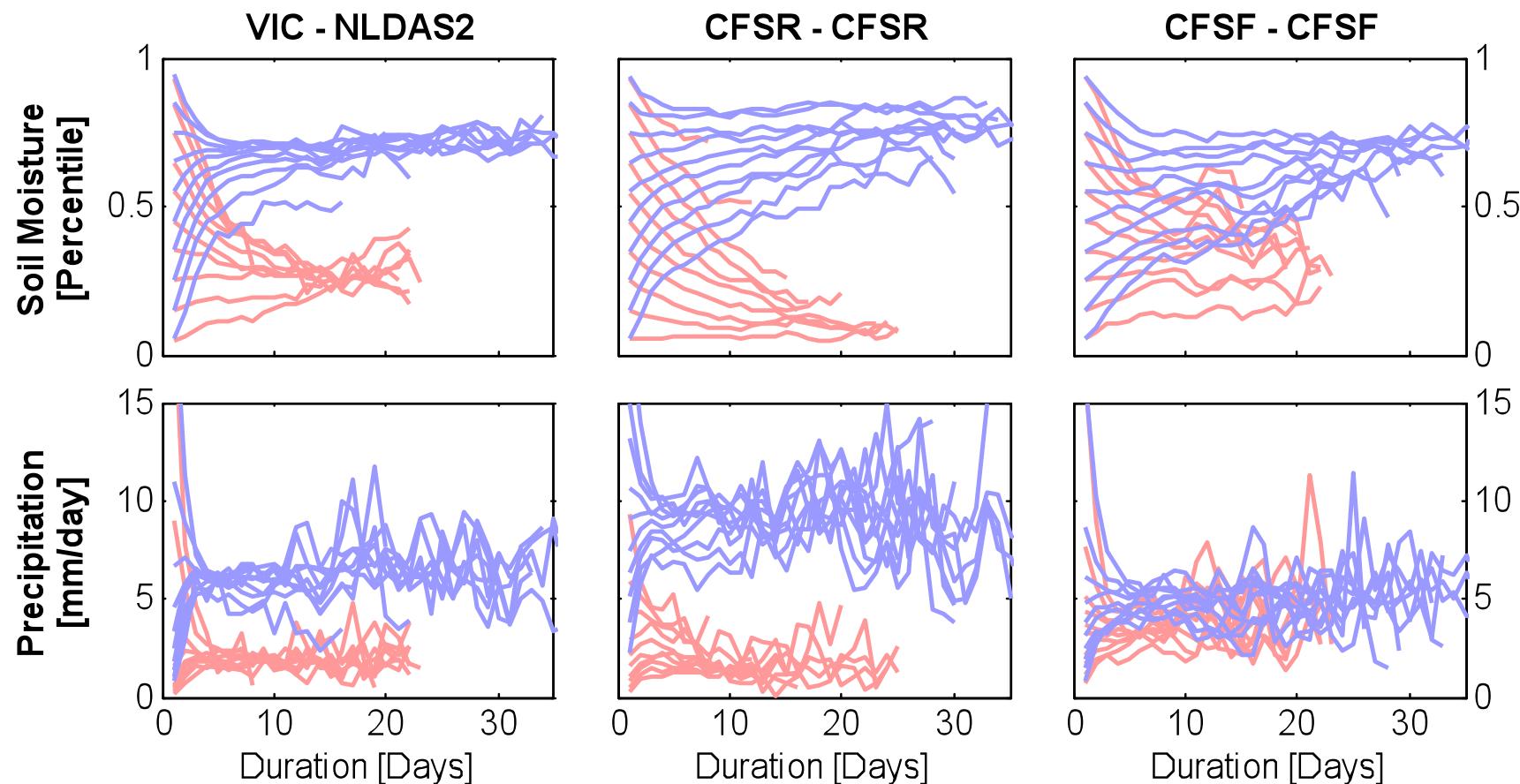
(Roundy and Wood, in preparation)

Coupling in the SE tends to last \sim 25 days in one state. Transition related to atmospheric processes but maintenance is probably has a land component.



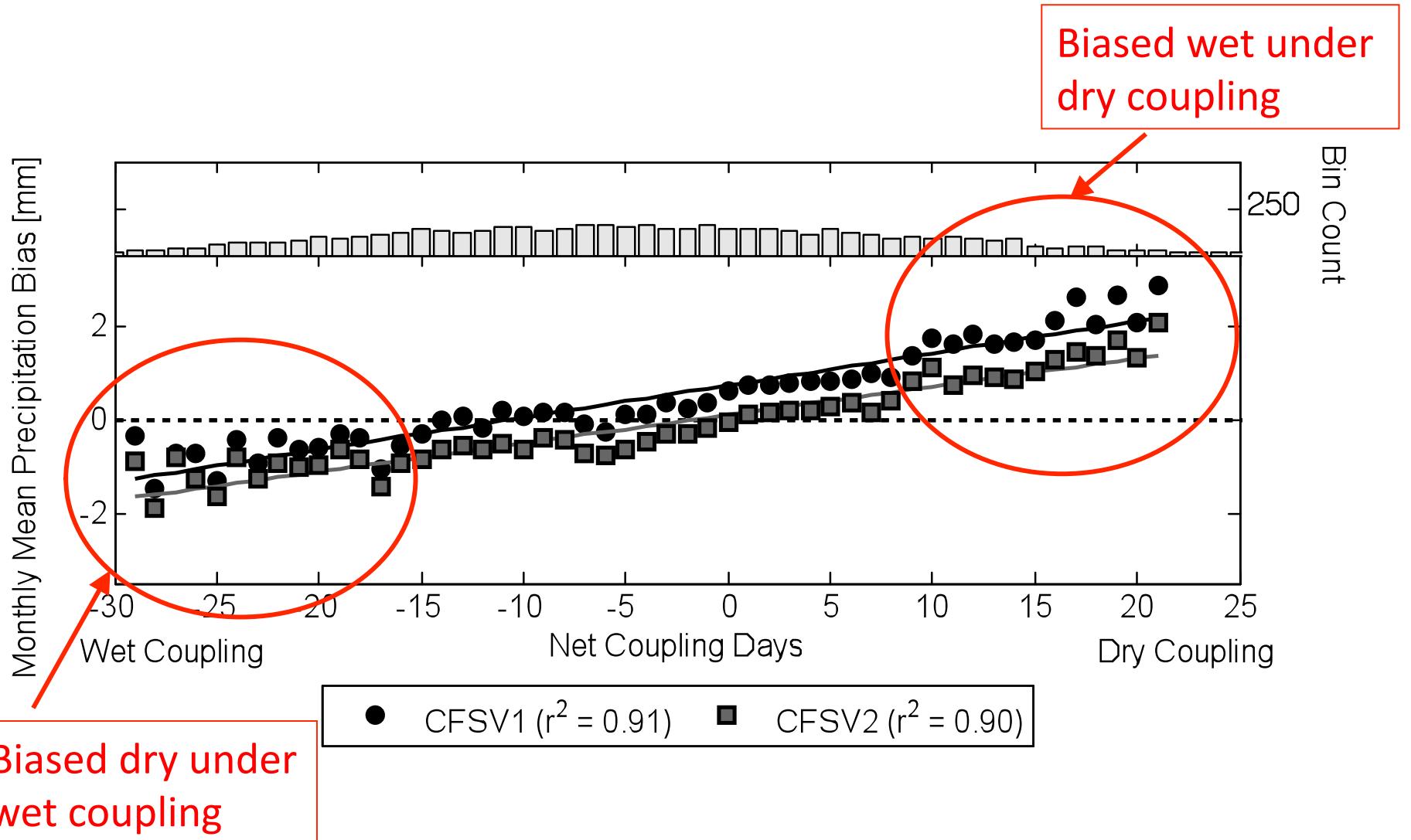
(Roundy and Wood, in preparation)

Binned evolution of soil moisture and precipitation from dry (red) and wet (blue coupling for off-line (VIC – NLDAS2), CFSR and CFSv2 (month 1). Note that initial SM has little impact on initiation of wet and dry coupling.



Average Soil Moisture and Precipitation for event duration for
CFSR (Reanalysis) and CFSF (Forecast).

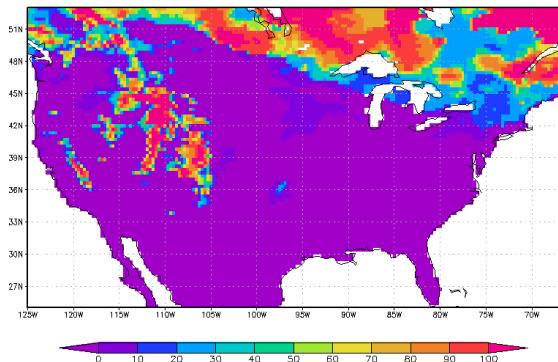
Bias in monthly mean precipitation with duration of coupling events.



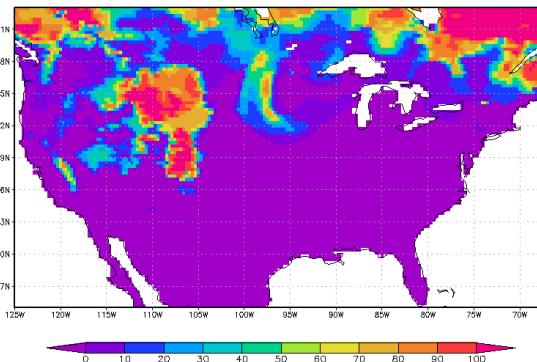
Comparison of Snow Cover Area (%)

CFS-R (12H, 01April)

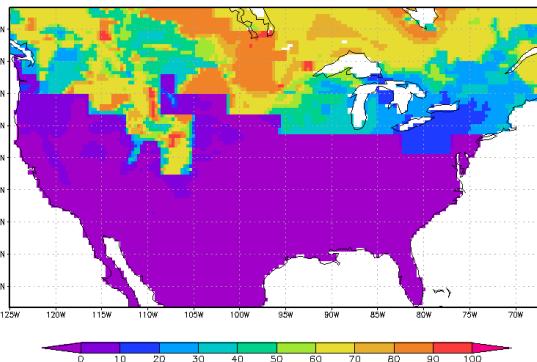
2005



2007

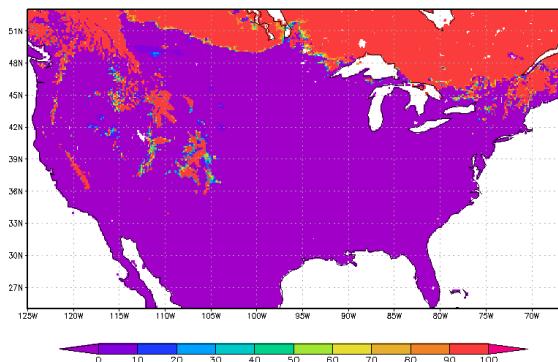


2009

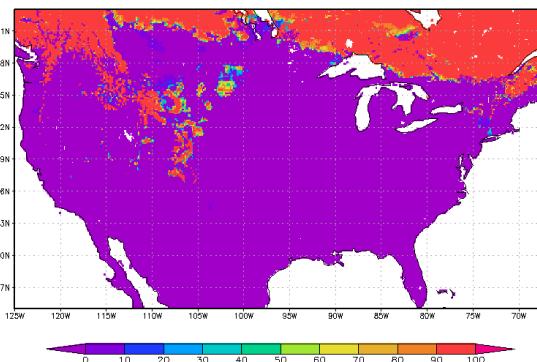


NLDAS - NOAH (12H, 01April)

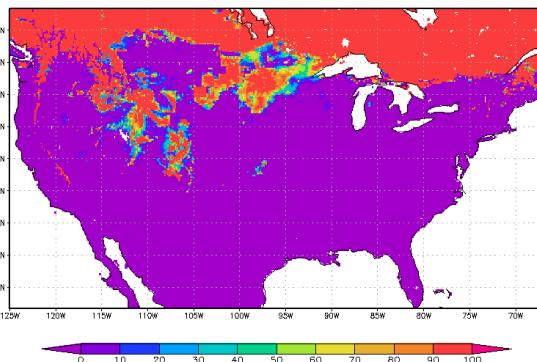
2005



2007

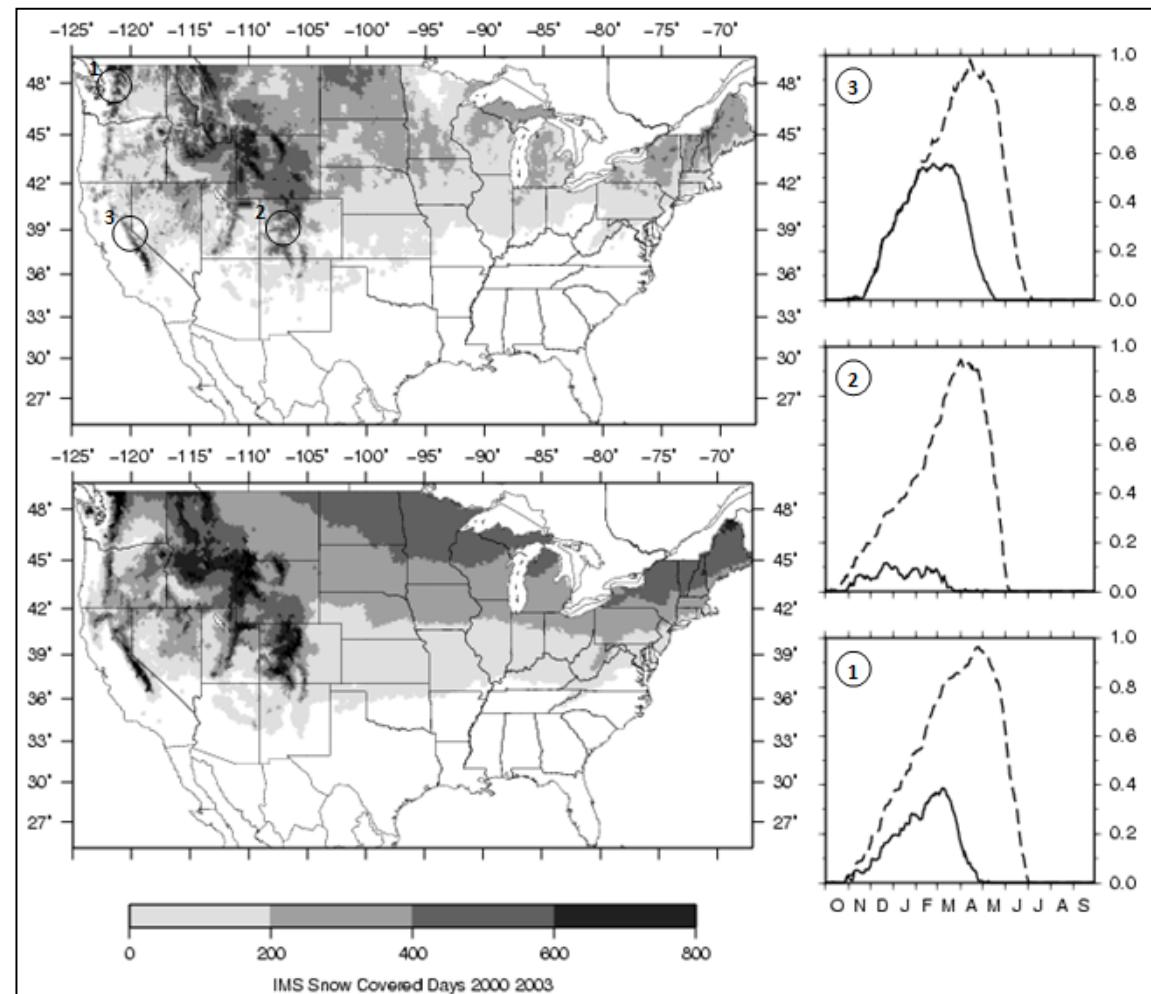


2009



Noah 2.7 snow cover prediction problems. Work at UW has shown that snow albedo (aging, etc.), atmospheric stability over snow covered regions and refreezing of melt water are the major problems related to snow processes. In Noah 2.8, the snow albedo correction has been implemented. (work at U Washington by Ben Livneh and Dennis Lettenmaier)

- Negative SWE bias noted in Noah LSM.
- Important for partitioning radiative inputs, fluxes (coupled mode) and capturing soil moisture anomalies and streamflow timing (hydrology).
- Prompted offline testing of various model components



Conclusions

1. CFSv2 is significantly more skillful than CFSv1 and **most** other NMME models (and EUROSIP models – see Yuan and Wood, GRL, 2011).
2. Drought prediction – especially the recovery of drought – is a challenge
3. Land coupling is a challenge, with systematic wet (dry) biases during dry (wet) conditions – a push to the mean.
4. There are still issues related to Noah2.7 with respect to snow processes, climate sensitivity, etc. -- work to do!